STUDY OF AN ILLUMINOMETER

BY

M. L. SUMMERFIELD

A. ZIMMERMAN

ARMOUR INSTITUTE OF TECHNOLOGY

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EXPERIMENTAL STUDY OF AN ILLUMINOMETER

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MYRON L. SUMMERFIELD AND ARNOLD ZIMMERMANN

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APPROVED:

E. N. Freeman
Professor of Electrical Engineering

Dean of Engineering Studies

Dean of Cultural Studies

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INTRODUCTION

With the advent of new illuminants, and the new methods of employing them which are constantly being devised, a comparison of their merits cannot be made without methods of measureing the light derived from them. Whatever the method of lighting adopted, it is the illumination derived in which the consumer is interested and for which he pays.

As early as I883, Sir WM. Preece pointed out that although measurements of the illuminating power of scources of light are very desirable, they do not strictly speaking, tell exactly that which it is desired to know. What is realy wanted, he pointed out, is, not only the amount of light given by the lamp used, but the actual intensity of illumination on the surface where the light is used, such as on the page of the book being read, on the picture on the wall, on the writing table, ETC.

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Many instruments for such measurements have been made most of which are designed on one or more of the following principles of photometry:

(I) Varying the distance between the comparison lamp and the screen,

(2) Dispersion lenses,

(3) Variable diaphragms,

(4) The use of absorbing media,

(5) Polarization media,

(6) Inclination of the illuminated surface,

(7) Variation of the intensity of the comparison lamp,

(8) The use of a contrast screen,

(9) Combination of two or more of the foregoing methods.

This work deals with an apparatus useing a contrast screen, a screen of paper with oil or grease on it to give the photo-

metric balance.

Credit for the invention of the first illumination photometer, according to A. P. Trotter, should be given to Wm. H. Preece. Mr. Preece describes, in a series of reports made by him to the Streets Committee of the Commissioners of the City of London, in August I884, the apparatus as follows:

> "I made my standard the amount of illumination given by a British candle fixed at I2.7 inches distance. This is very easily reproduced, and it is the same illumination as that given by the French standard light when fixed at a metre distance..... Our instrument for the purpose must be light and portable, for it had to be moved about the streets. It required to be easily repriducible at any time and place, and to be absolutely uniform....I took my idea from the fairy lamps

used at the Savoy Theatre in "Iolanthe". Here we had something portable, uniform and very easily manufactured. One of these lamps was placed inside a small box, the top of which had a screen of white paper on which was a grease spot. I was able, by increasing or diminishing the current of electricity producing the light, to vary the illumination of one side of this grease spot. When it was desired to measure the illumination of any space, such as the surface of the street, this box had simply to be put at the place to be measured, and the current had to be regulated until the grease spot disapeared. The current of electricity then became the measure of the illumination abd a simple table gave the result in terms of the new standard."

After the work of Mr. Preece many illumination photometers were designed most of which

had their point of balance always fixed, the balance being determined by moving of the standard scource of light, by inclining the screen, the use of mirrors or some other such device. Recently, however, two men came out with devices which are practically alike, one described in the American Gas Light Journal of August 1916, the other described in the Lighting Journal of November 1916. This apparatus has a direct reading scale and is the one upon which this work is based. Its details and construction are given in the following pages in which are also given the method of study of the apparatus.

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Construction of Illuminometer

The illuminometers as described in the American Gas Light Journal and the Lighting Journal were about ten inches long with a one inch square opening running their lengths. Over this opening was placed the screen, which was a piece of paper treated throughout its length over a narrow strip to give that strip a waxed appearance. The exact treatment of the screen was not given. At one end of the box was placed a small tungsten lamp (about four volts).

The purpose of this work being to study this type of illuminometerexperimentally, it was decided to build one about four times the size of those described in the journals with the idea in view of obtaining a greater range and more accurate readings.

The box built with this in view is detailed in Fig. I and shown in the illustrations of Fig's. 2 & 3. From the dimensions of Fig. I, it can

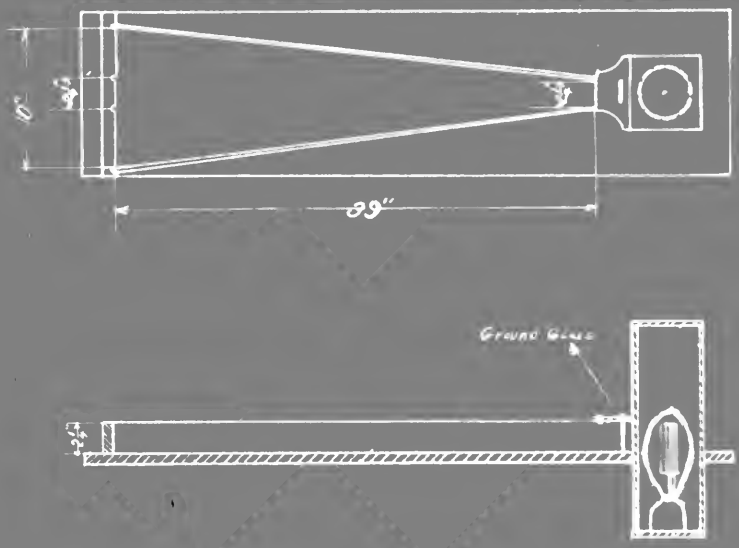

Figure I

be seen that a scale of about three feet is to be expected. The sides of the box were so they could be widened at the end farthest from the lamp, from 2¼ inches when parallel to 10 inches, this widening being only at the end farthest from the lamp, the ends by the lamp being rigidly fastened at the 2¼ inches.

The box being built, the question of making a screen came up. In studying over this matter A. Palaz's "Treatise on Industrial Photometry" was found to contain the following methods for making photometer screens:

(1) Toepler screen: Sheets of white paper pirced with a circular hole, covered on each side with a sheet of tracing paper and put together without glue.

(2) Two thin pieces of white cardboard pierced with a hole and between them a sheet of tracing paper.

(3 & 4) Kruss screen: Sheets of white school paper with paraffine spot.

Fig. 2

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(5) White cardboard pierced and covered with a sheet of tracing paper blackened with plumbago so as to have unequal faces.

(6) Two sheets of white paper exactly alike, pierced and covered on each side with a sheet of tracing paper.

(7) Two sheets of white paper, between which is a sheet of tracing paper.

(8) Oiled paper, the spot being formed on each side by a band of white varnish.

Numbers 3 & 4, the Kruss screens, appeared to be the nearest to those described in the American Gas Light Journal and the Lighting Journal, attempts were thus made to apply paraffine to a sheet of white paper. The intention was to make a screen similar to that described in the Lighting Journal and have the treated portion of the screen consist of small diamonds to give the effect seen in the pictures of Fig's. 2&3.

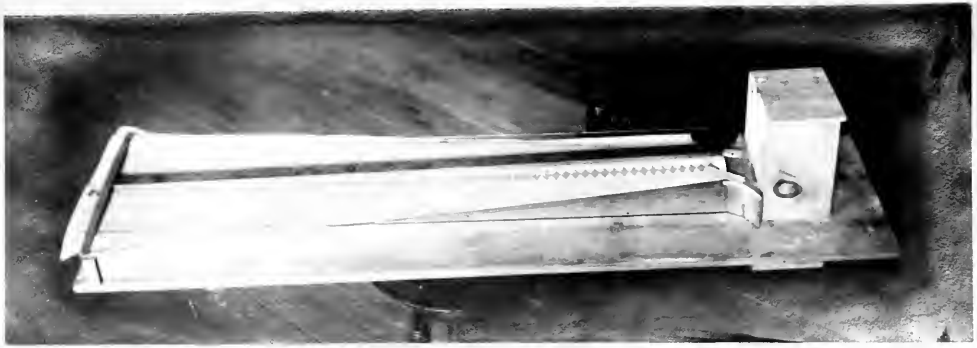

Fig. 3

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Detail drawing papers of various weights were obtained. Then molten paraffine was taken and painted on this paper in the pattern wanted. The paraffine, however, ran and no definite pattern could be held. The next step was to try to find a solvent for the paraffine the idea being to get a solvent which would evaporate when applied to the paper, leaving the paraffine. No solvent could be found for the paraffine, the nearest to a solvent being benzole, which left the paraffine in a granulated state. Painting molten paraffine onto the paper was again attempted, this time a pattern being cut from some heavy drawing paper and this placed over the detail paper and the paraffine painted over this. A screen was made in this manner, the diamonds of which, however, were not very regular. This screen was placed on the box and the lamp in the box lighted. After the lamp had been burning for

about five minutes the paraffine for a distance of about ten inches at the end of the box near the lamp started to spread and in a short time the screen was spoiled. This was the end of attempts to make a paraffine screen.

Oiling a sheet of paper was now tried the oil was painted on the screen in the same manner as the molten paraffine. Here it was found that the detail papers were useless for this purpose as the oil spread through the paper almost as soon as it was applied. Samples of printing papers were obtained, the samples ranging from course cheap papers to fine heavy bonds. In trying the courser papers, it was found that the oil spread very easily; but upon trying the bonded papers, one which took the oil in the pattern wanted was found. At first this was considered a successful screen;but the next day it was found that the oil had spread spoiling this screen.

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The next screen made consisted of two sheets of detail paper between which were placed a third sheet of the same paper which had been oiled. The diamonds had been cut out of the two sheets of untreated paper. This combination gave the best combination as yet obtained. The untreated paper being slit in the middle bulged away from the oiled paper, throwing a shadow on the oiled paper. To prevent this trouble the screen was placed between two plates of glass. After lying between the two sheets of glass for some time, the oil soaked into the untreated papers thus spoiling the screen.

Some parchment tracing paper was secured and placed between the two sheets of detail paper in which the diamonds had been cut out. The parchment tracing paper is a treated paper which is unaffected by the heat of the lamp, contains no oil or anything which would affect the untreated papers of the screen. These

advantages, however, were counterbalanced by the fact that apparantly the parchment paper absorbed too much light.

As a last resort a screen was made without having a definite pattern on it. For this screen a heavy detail paper was used and on this was allowed to drip candle-grease. The drops were put on without any definite arrangement the only limitations being that they should not touch one another. They were also kept within a band about one inch wide. It was found upon putting the screen on the box that the spots for a distance of about eight inches of the ground glass were so bright as to be indistinguishable; but upon grinding the second side of the glass, the spots showed up very clearly, the point of balance being well defined. This screen was not affected by the heat of the lamp as was the paraffine screen, nor did the candle-grease run as was the case with the oil screen.

Fig. 4

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Calibration and Results

Calibration refers to how the ilumination on the screen varies from the end by the lamp to the other end of the screen. The method of calibrating the scale of the box was a detail upon which there was not much choice. The box was too large to even try to photometer and even if such a proceeding were to be tried the whole screen with the exception of that part being photometered would have to be covered. This would in itself give readings different from what they would be under actualworking conditions. It was finally decided to callibrate by having a lamp of known candle-power over the screen and determine the points of balance for various heights of this lamp. The box with the lamp over it is shown in the picture of Fig. 4. The point of balance is that point on the screen where the treated portion changes from light to dark; theoretically at this point the treated

portion of the screen cannot be distinguished from the untreated part.

The screen was callibrated with the sides of the box parallel and also with them flaring. By flaring is meant that the ends farthest from the lamp were spread out. Since the other ends of the box were rigidly fastened, the side pieces were curved for this condition.

The first screen for which any results were obtained, was the screen made of an oiled paper placed between the two sheets of untreated paper. For these results there was an observer on each side of the screen, one checking the other's readings. One of the best sets of data obtained with this screen is given in the following table, the curves of Fig. 5 being for these data.

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Data for Curves of Fig. 5

CP. of lamp outside of box	Height of lamp in ft.	Distance on screen for balance	Ft. candles on screen
	Parallel Sides		
5I.I3	3	7.I5	5.68
5I.I3	4	9.69	3.2
28.84	4	I2.I8	I.8
28.84	5	I6.34	I.I5
28.84	6	I9.06	0.8
28.84	7	20.93	0.588
	Flaring Sides		
5I.I3	3	5.97	5.68
5I.I3	3.5	7.78	4.I6
5I.I3	4.5	9.69	2.5
5I.I3	5.5	I0.87	I.675
28.84	5.5	I2.78	0.945

The curves show that flaring the sides of the box makes the scale shorter and when taking the readings it was noticed that for the flaring sides the points of balance were not as distinct as they were for the parallel sides.

When it was found that the oiled paper screen spoiled quickly, the parchment screen was used. This screen gave curves of the

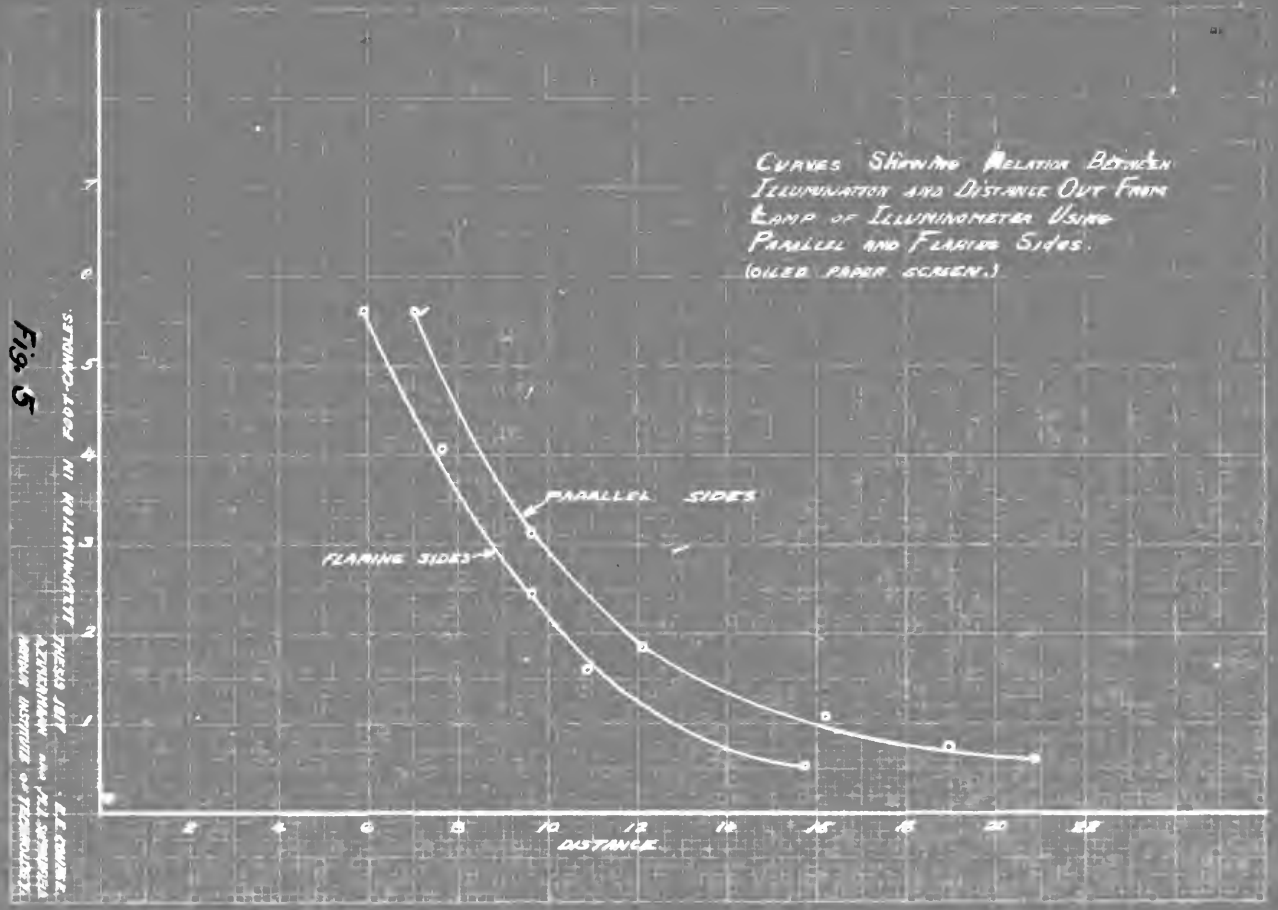
CURVES SHOWING RELATION BETWEEN ILLUMINATION AND DISTANCE OUT FROM LAMP OF ILLUMINOMETER USING PARALLEL AND FLARING SIDES. (OILED PAPER SCREEN.)
PARALLEL SIDES
FLARING SIDES
DISTANCE
7
6
5
4
3
2
1
4
6
8
10
12
14
16
18
20
22

Fig 5

same nature as those given with the oiled screen only the distance on the screen for which a balance was obtainable was very short. The points of balance for this screen were not as sharply defined as those for the oiled paper screen. The distance by which the readings of the two observers differed, was from one to three inches. This lack of agreement was attributed to the fact that there was a slight color difference between the parchment and the and the detail paper. The difference may also have been due to the fact that the parchment absorbed too much light.

The screen made by dropping candle-grease on a piece of detail paper was the one finally used, it gave a good sharp point of balance when a piece of ground glass ground on both sides was used in place of the former one which was ground only on one side. The distance on

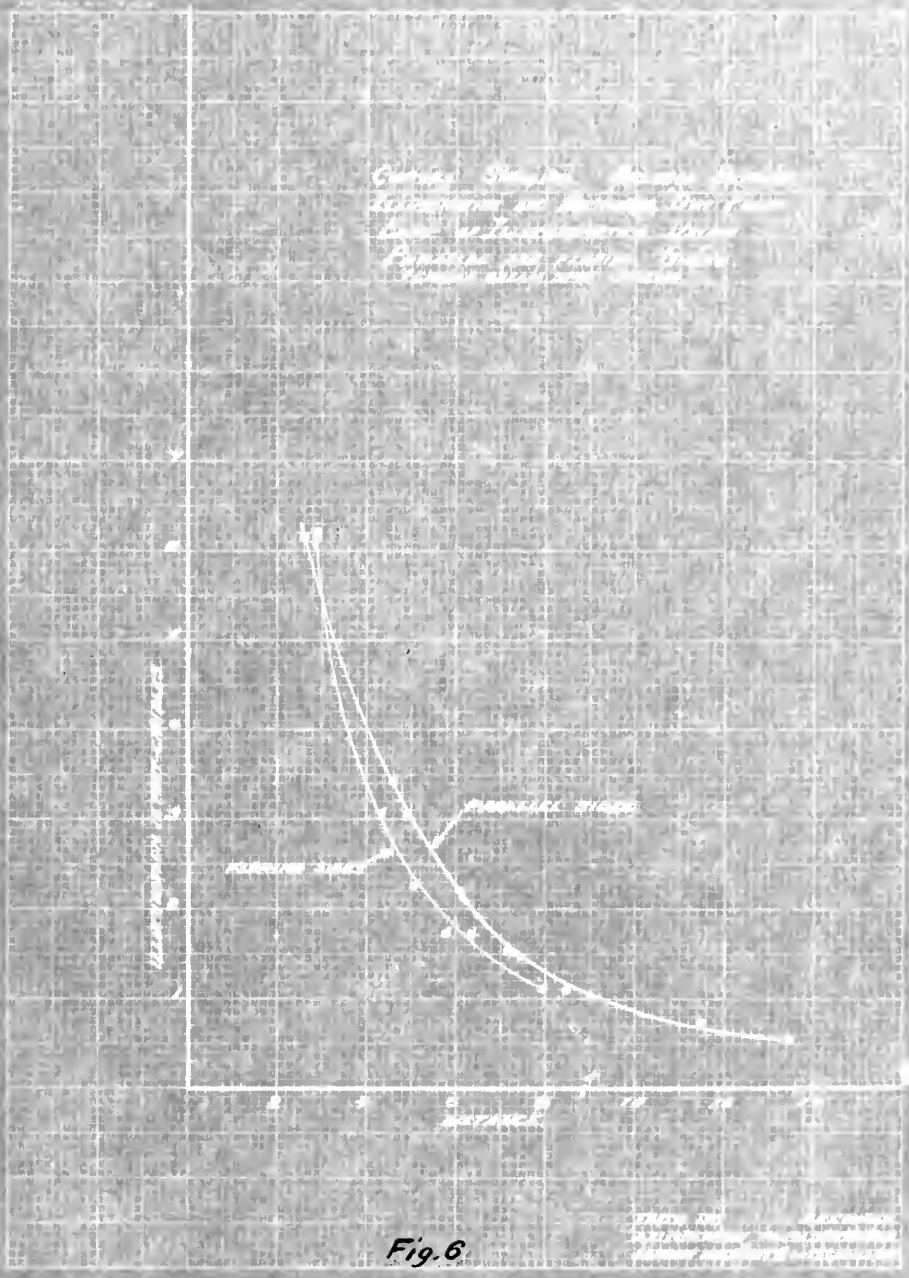

Fig. 6

the scale for which a balance was recognizeable was about thirteen and a half inches, whereas for the oiled screen it was about twenty inches. A set of data taken by one observer is given in the following table, the curves for these being shown in Fig 6.

Data for Curves of Fig 6

CP of lamp outside of box	Height of lamp in ft.	Distance on screen for balance	Ft candles on screen
	Parallel Sides		
55.5	3	2.5	6.17
55.5	4	4.5	3.47
55.5	5	6.0	2.22
27.8	7	13.5	0.568
27.8	6	11.5	0.773
27.8	5	8.25	1.11
27.8	3	4.75	3.09
	Flaring Sides		
27.8	3	4.25	3.09
27.8	4	5.75	1.737
55.5	3	2.75	6.17
55.5	5	5.00	2.22
55.5	7	8.00	1.134

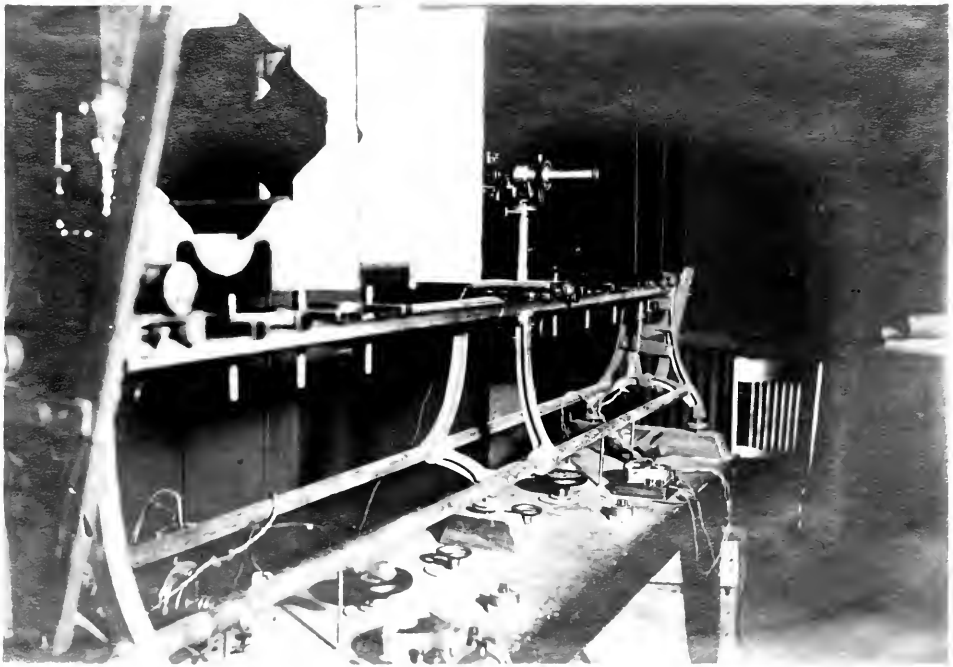

Fig. 7

A comparison of the two sets of curves would seem to indicate that the last screen used gave sharper points of balance than the screen made up of two plain pieces of paper with an oiled one between them.

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